ANALYZING CHANGES IN THE SPATIAL DISTRIBUTION OF SAGUAROS (Carnegiea gigantea) IN SAGUARO NATIONAL PARK

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MSc Natural Resources
Watershed Management and Ecohydrology
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Goals/Objectives

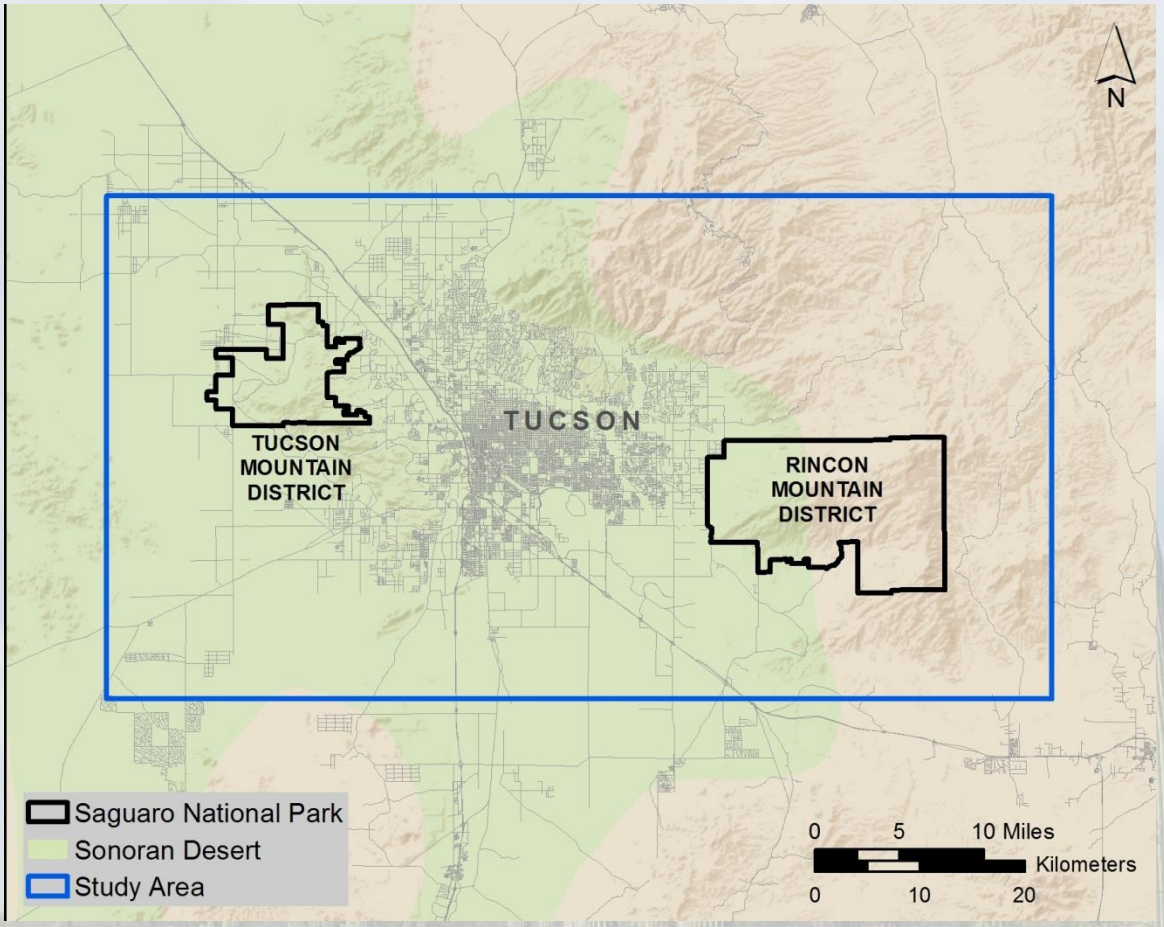
1. What was the probability/suitable habitat of saguaro in 1975?
2. What was the probability/suitable habitat of saguaro in 2010?
3. How has saguaro distribution changed in the 35 years as a whole?
4. How has saguaro distribution changed in the 35 years by height class?
5. What environmental variables are the most influential in determining suitable habitat?
6. What are the implications for management and future research?

Sonoran Desert

- >100,000 mi² (260,000 km²)
- Basin & Range: rocky hillsides and bajadas, sandy flats and dunes, sky islands
- Below sea level to 10,000ft (3,000m)
- 20 – 104°F (48°C)
- 3-20in (76-500mm)
- 99% of terrestrial biomes
- >3,500 known species, incl. 5 columnar cacti
  - Cardon (*Pachycereus pringlei*)
  - hecho cactus (*Pachyereus pectin-aboriginum*)
  - senita cactus (*Lophocoreus schotti*)
  - organ pipe cactus (*Stenocereus thurberi*)
  - saguaro *(Carnegiea gigantea)*

Saguaro (*Carnegiea gigantea*)

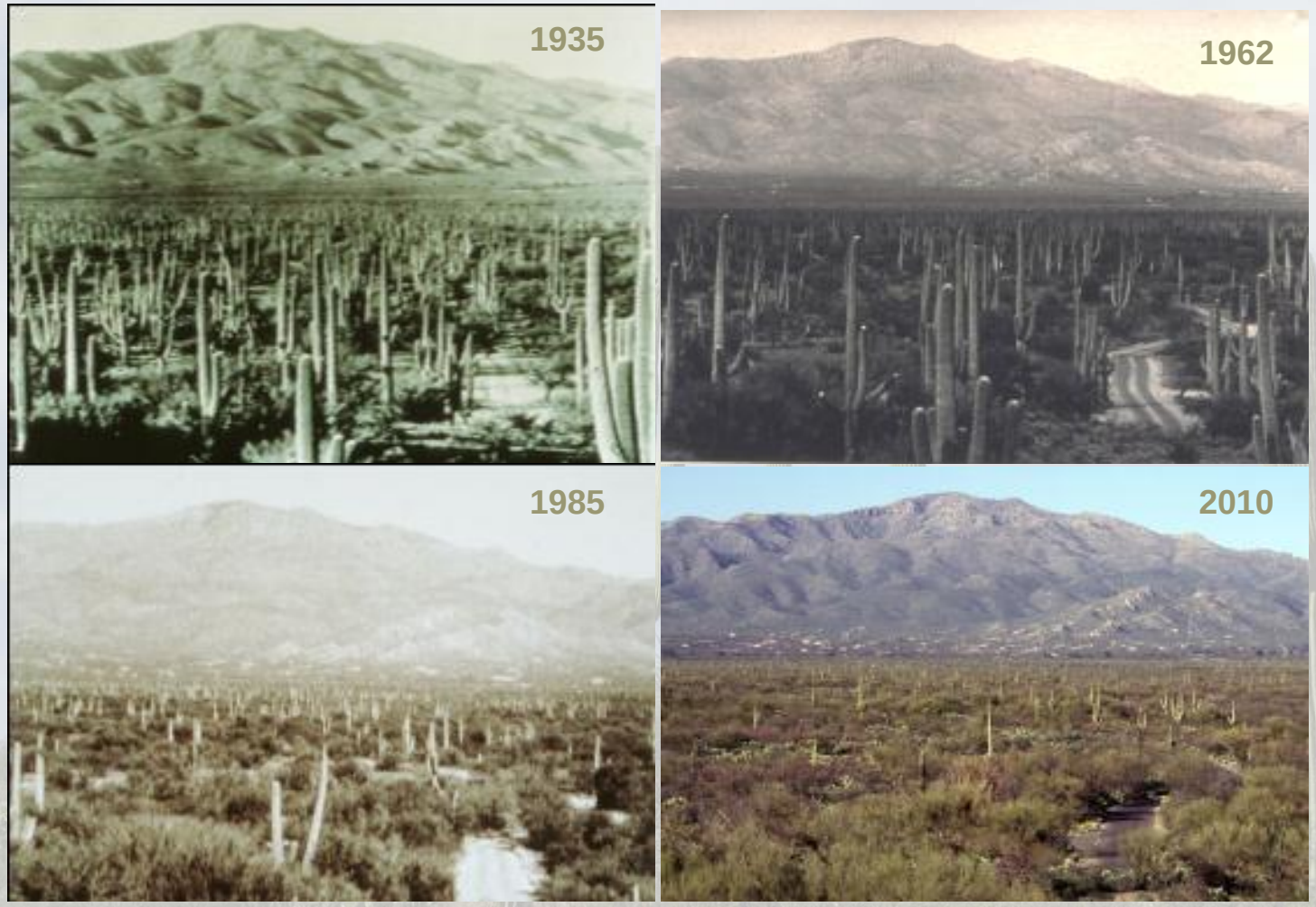
- Tree-like columnar cacti with branches (arms)
- Eastern portion of Sonoran Desert
- Sea level to ~5500 feet (1680 meters)
- Slow growing, live to be 150-200 years old (or more)
- 12-18 meters tall (40-60 feet)
- Spines
- White waxy flowers bloom for one night April-June



Saguaro National Park

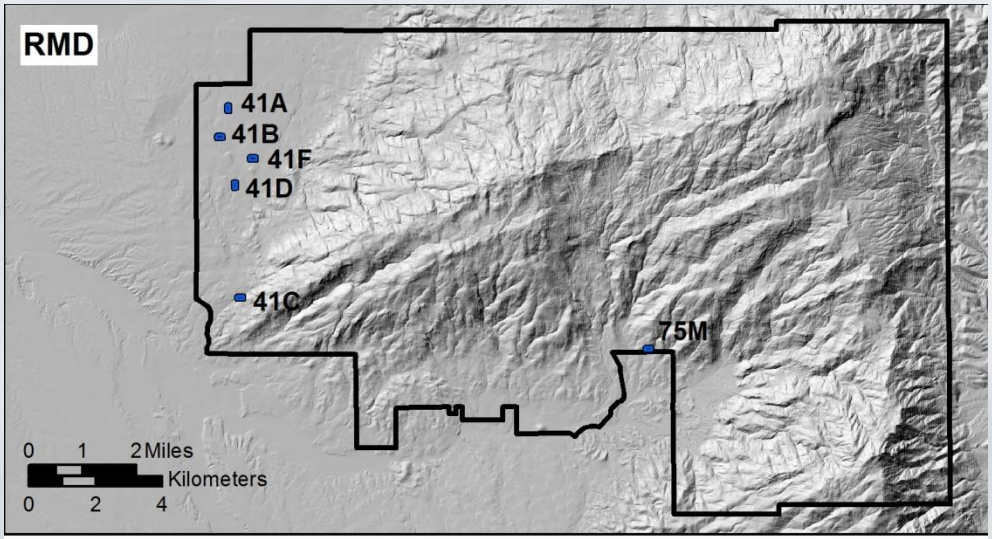
- Tucson, AZ
- Eastern edge of the Sonoran Desert
- Created in 1933 (as Monument) to protect saguaro, especially the "Cactus Forest"
- Expanded in 1961, 1976, 1991, and 1994, and converted to Park
- Study area includes 1 km buffer around the Park
- Two districts
  - RMD
  - TMD

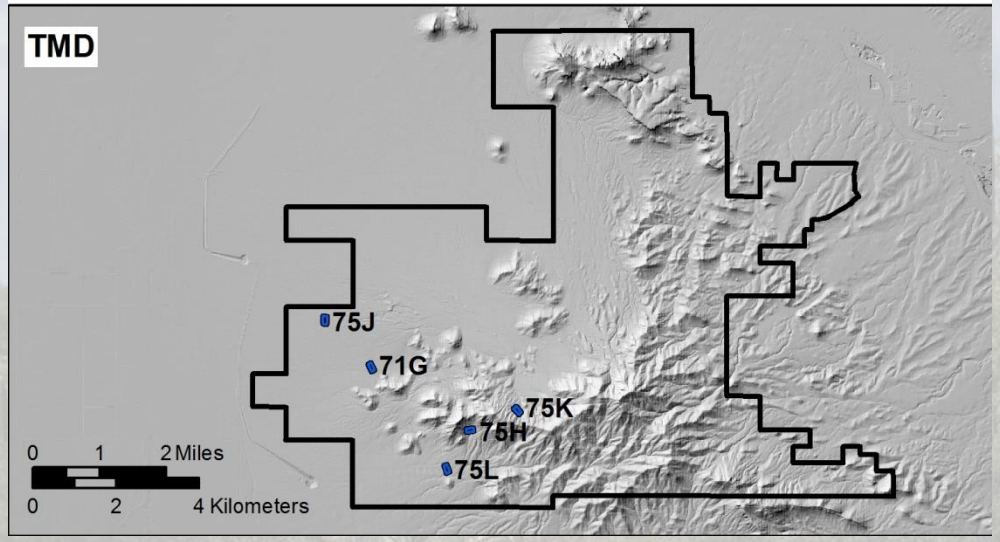
Cactus Forest

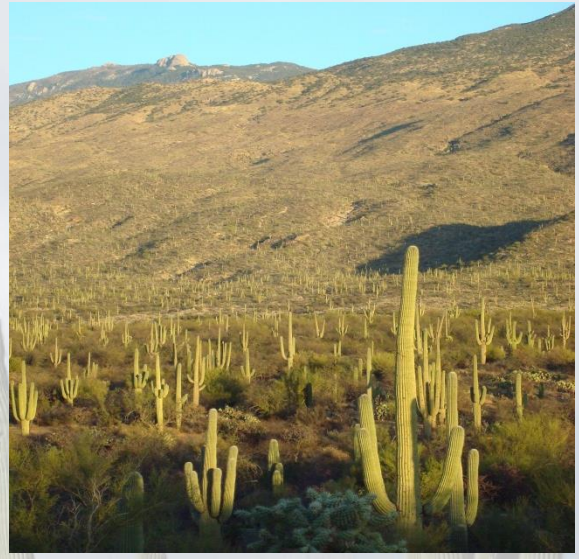


Photos by Ray Turner, USGS.

Historic Saguaro Plots







NPS Photos

Census Data Collection

- GPS coordinate
- Height
- Number of arms
- Number of holes
- Tag ID
- Other notes

NPS Photos

Data Compilation

Table

Saguaros

PLOT	TAG	UTM_X_83	UTM_Y_83	HT_1975	HT_2010	ARMS_1975	ARMS_2010	NOTES_1975	NOTES_2010	HOLES_2010	class_1975	class_2010
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41A	53	525675.643	3564282.059	4.19	6.5	10	8	excellent		0	2	3
41A	54	525678.052	3564286.022	5.095	13	0	8	fair; double cro	54?	2	3	5
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41A	N/A	525670.608	3564238.195	<Null>	1.65	<Null>	0	<Null>		0	N/A	1
41A	36	525674.305	3564227.474	9.69	0	6	0	fair	dead	0	4	DEAD
41A	35	525676.436	3564229.611	7.57	0	4	0	good	dead	0	4	DEAD
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41A	19	525681.218	3564192.143	5.525	0	3	0	fair; 2 arms at to	dead	0	3	DEAD
41A	18	525682.392	3564192.976	7.625	0	2	0	good	dead	0	4	DEAD
41A	20	525681.170	3564194.120	2.24	4	1	0	fair; top injured,		3	1	2
41A	22	525679.465	3564192.897	3.79	0	0	0	good	dead	0	2	DEAD
41A	24	525681.044	3564193.324	6.79	0	1	0	fair	dead	0	3	DEAD
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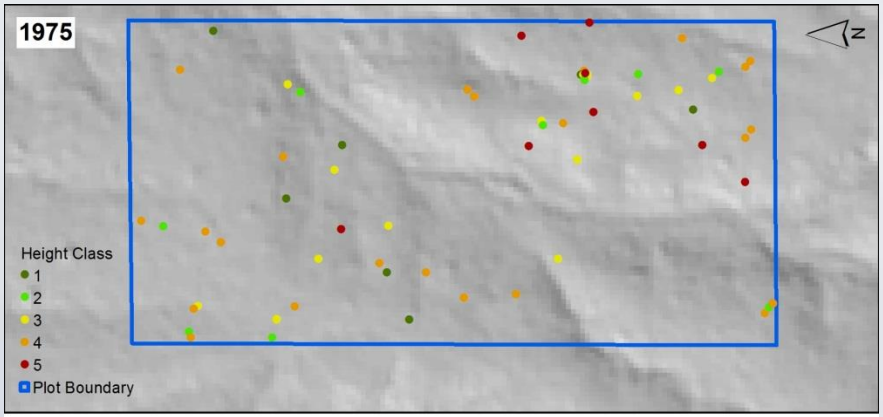
0 (0 out of 3175 Selected)

Height Classes (meters)

- 1= 0.00-2.49
- 2=2.50-4.99
- 3=5.00-7.49
- 4=7.50-9.99
- 5=10.00+

41A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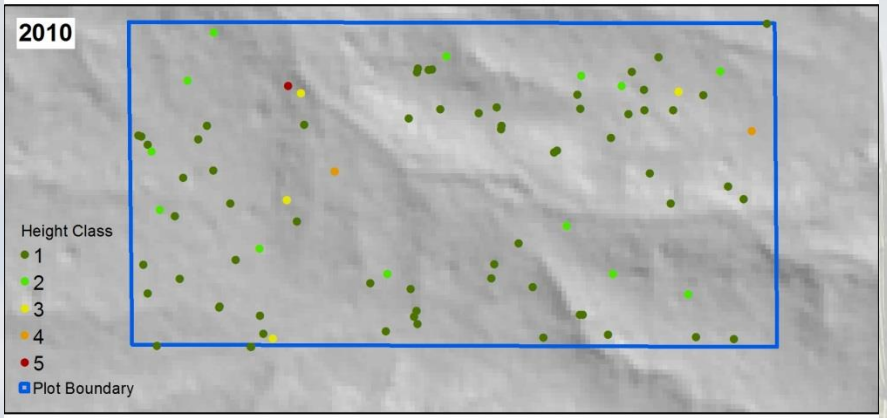
Plot Boundary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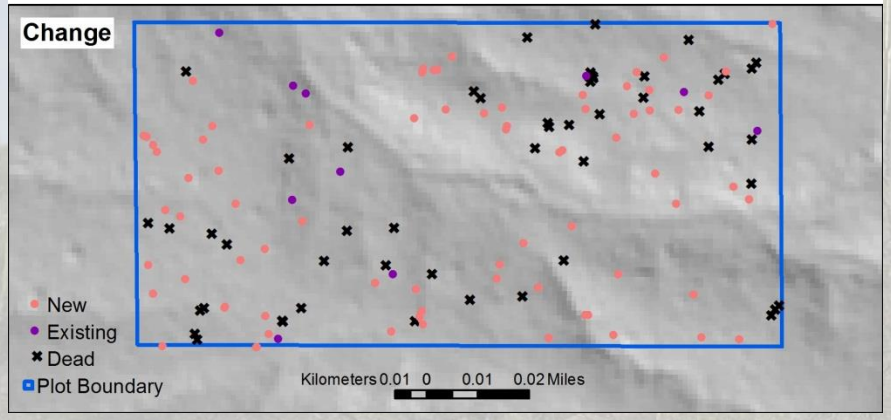
Plot Boundary


Change
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Kilometers 0.01 0 0.01 0.02 Miles

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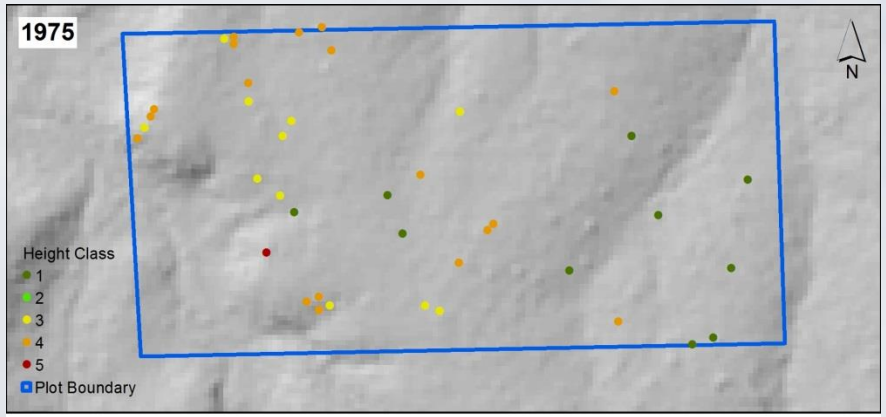
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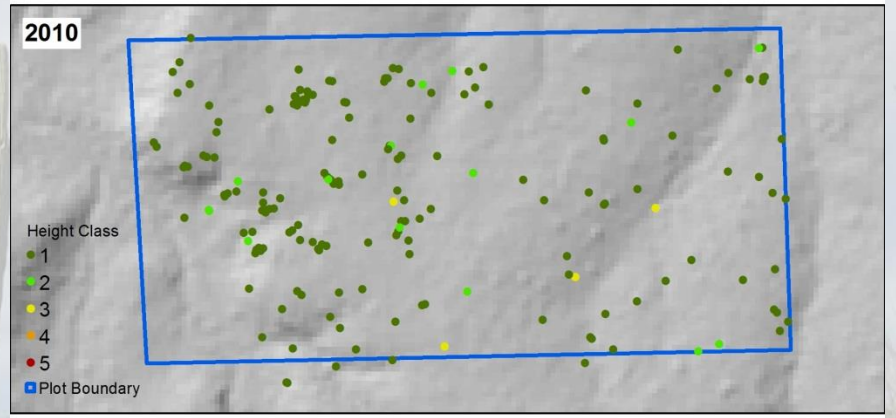
Plot Boundary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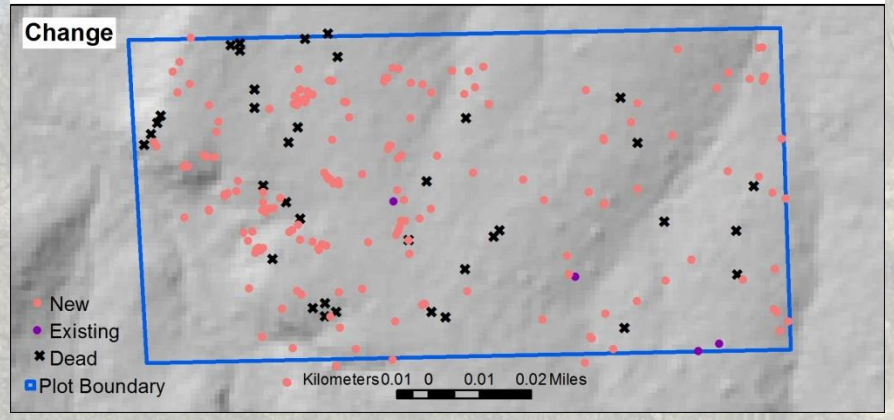
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Plot Boundary
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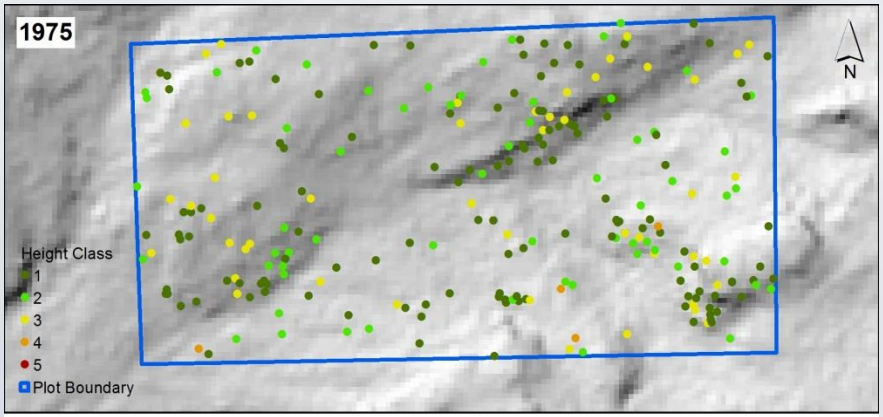
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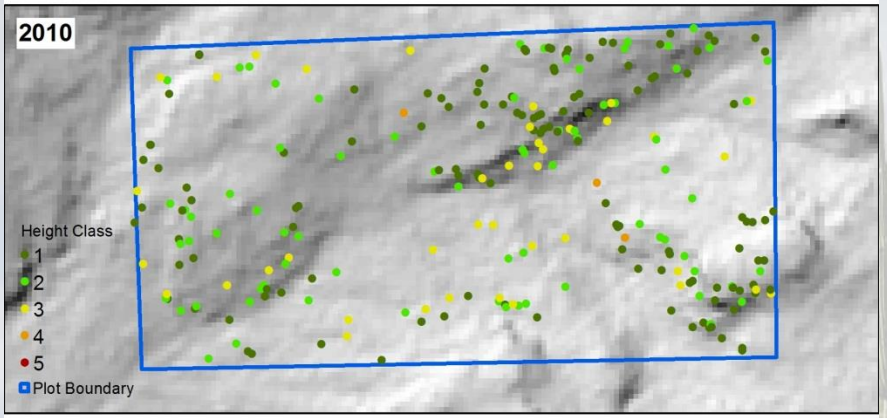
Plot Boundary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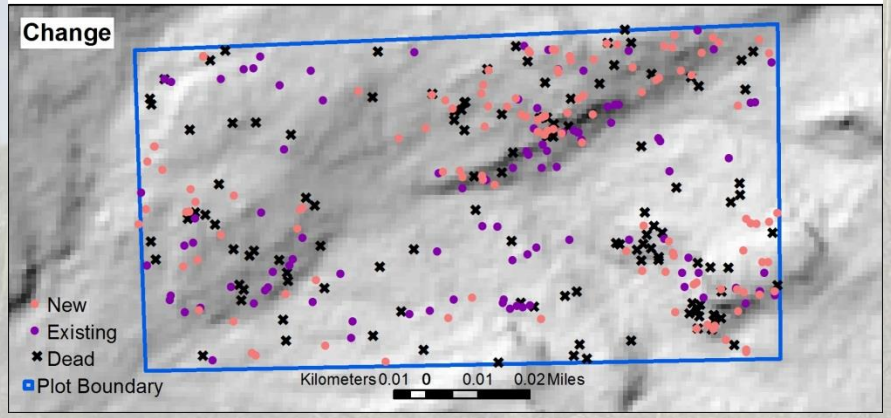
Plot Boundary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Kilometers 0.01 0 0.01 0.02 Miles

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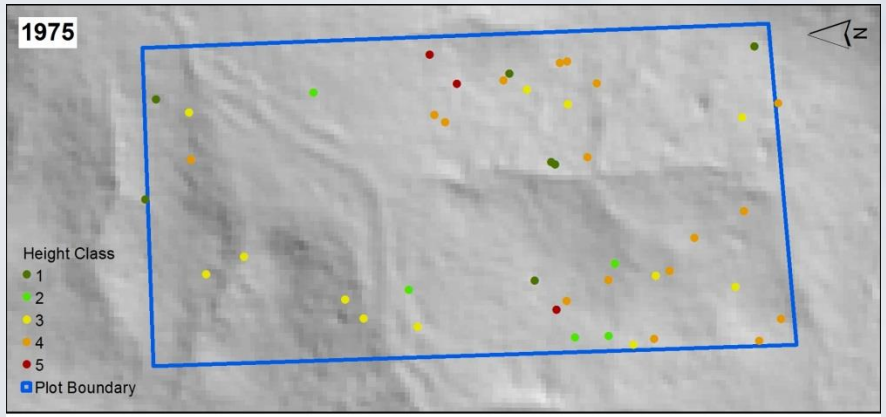
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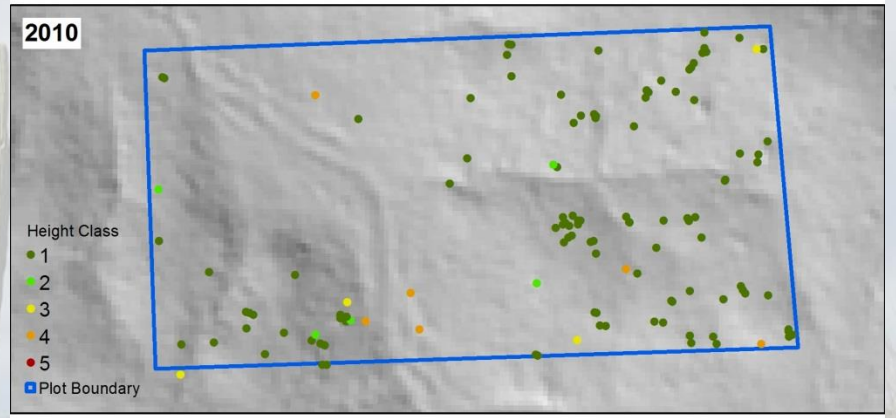
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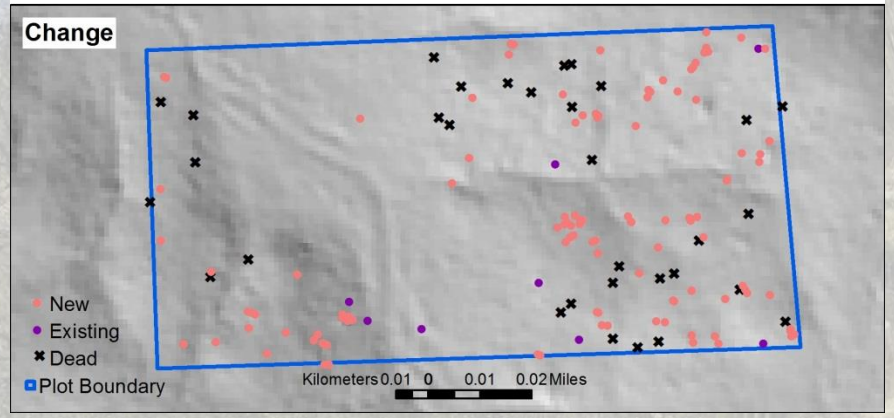
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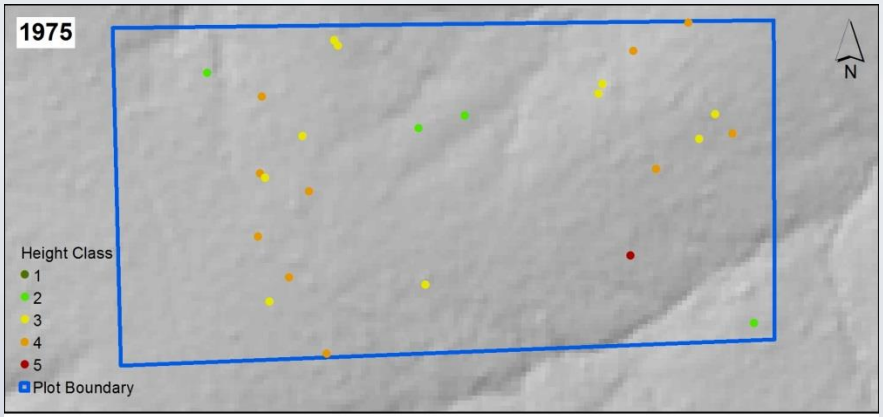
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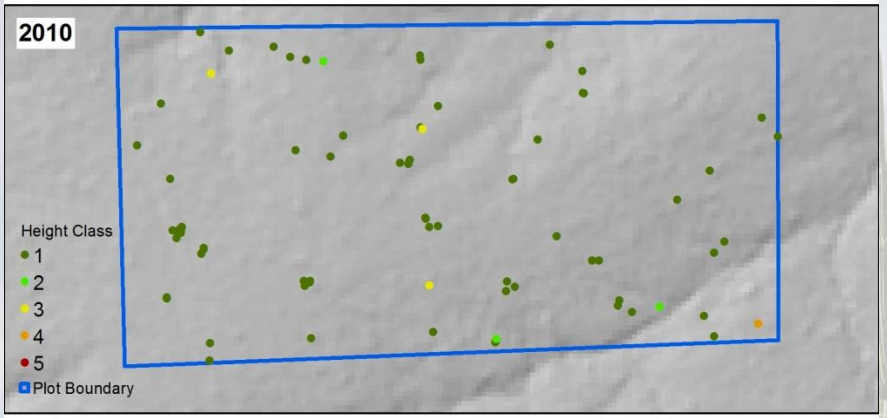
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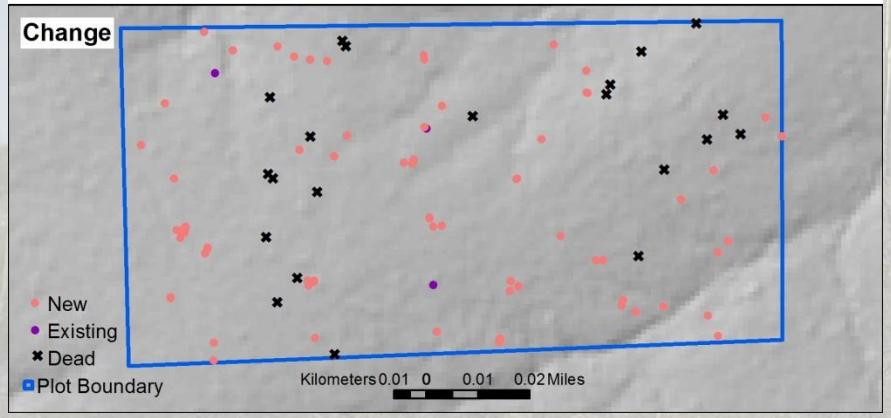
Plot Boundary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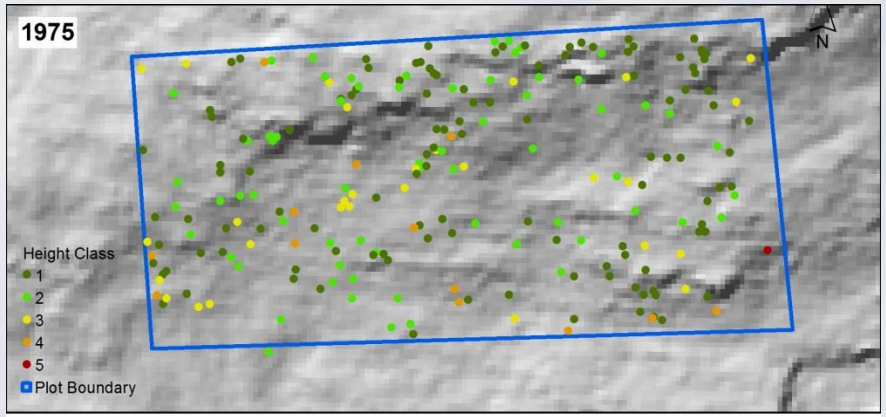
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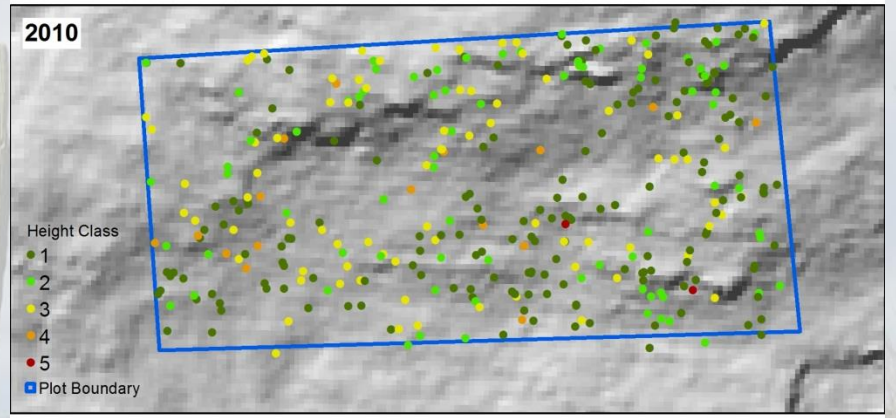
Plot Boundary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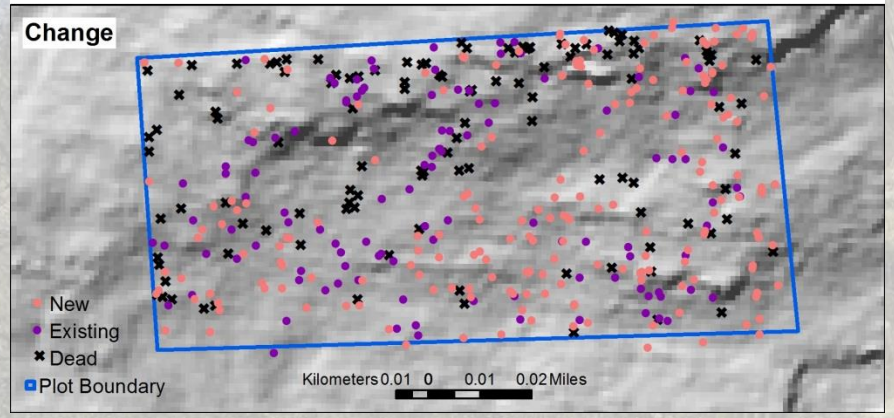
Plot Boundary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Plot Boundary
Kilometers 0.01 0 0.01 0.02 Miles

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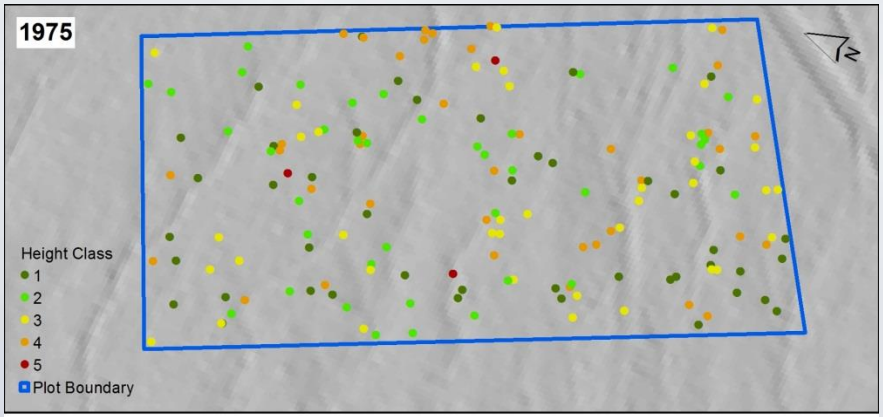
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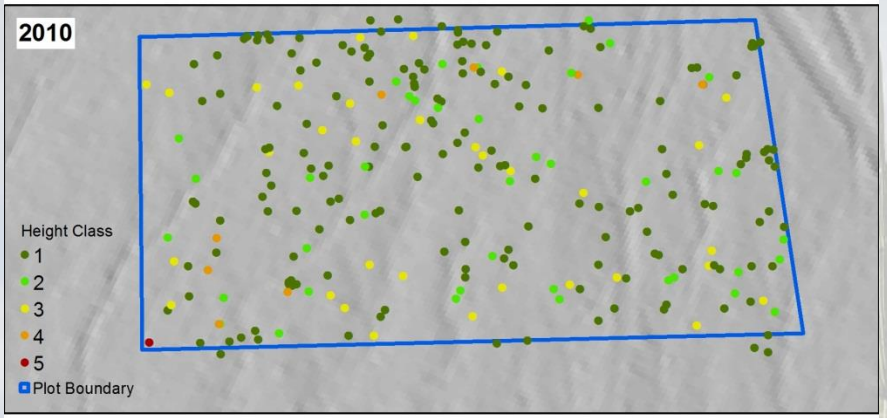
Plot Boundary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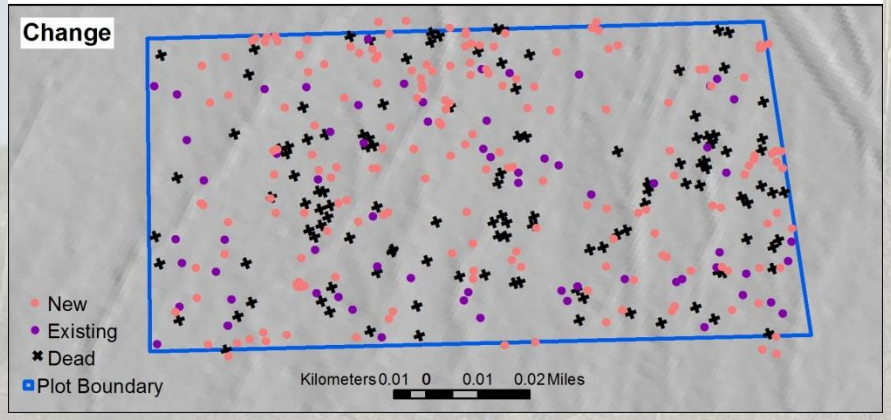
Plot Boundary


Change
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Existing
Dead
Plot Boundary
Kilometers 0.01 0 0.01 0.02 Miles

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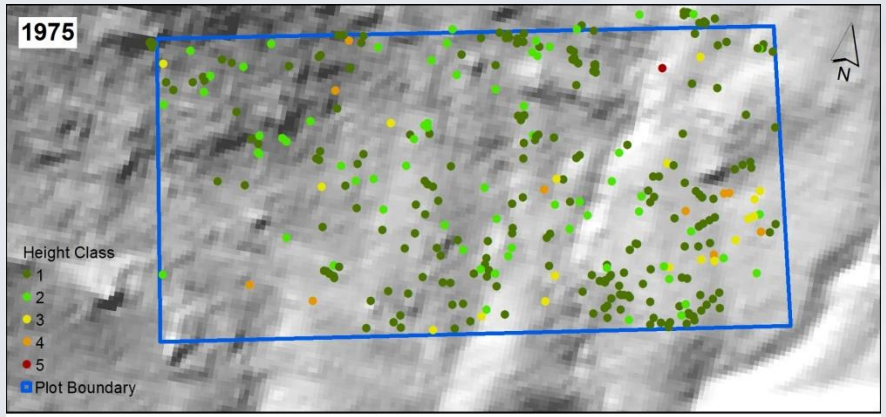
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Height Class
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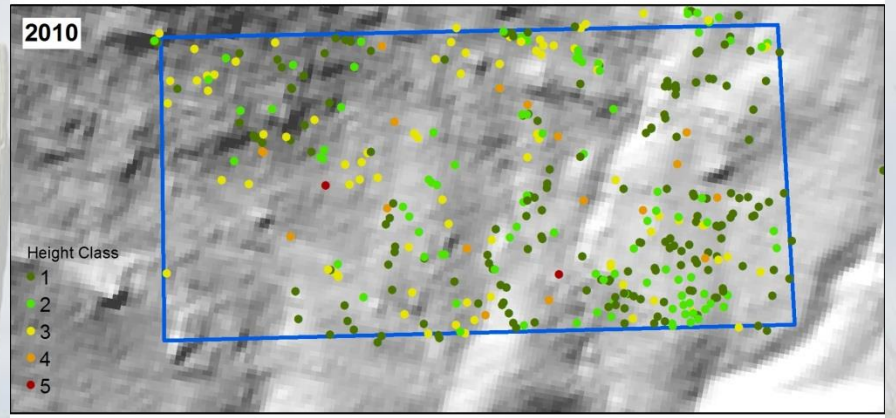
Plot Boundary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Height Class
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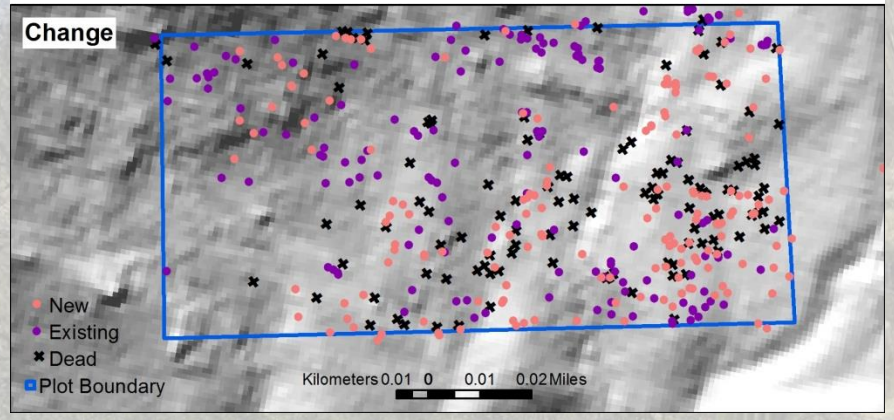
Change
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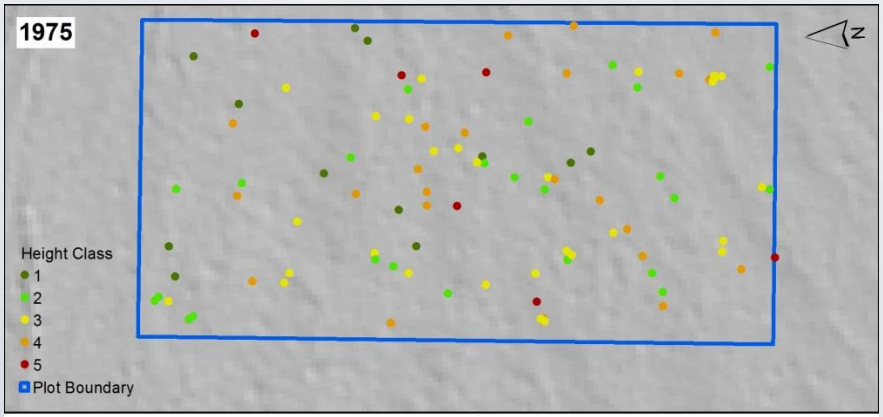
Dead
Plot Boundary
Kilometers 0.01 0 0.01 0.02 Miles

75J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Height Class
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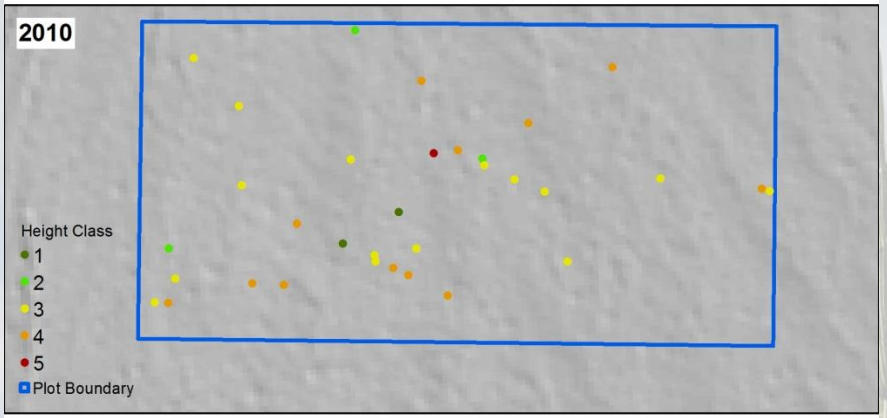
Plot Boundary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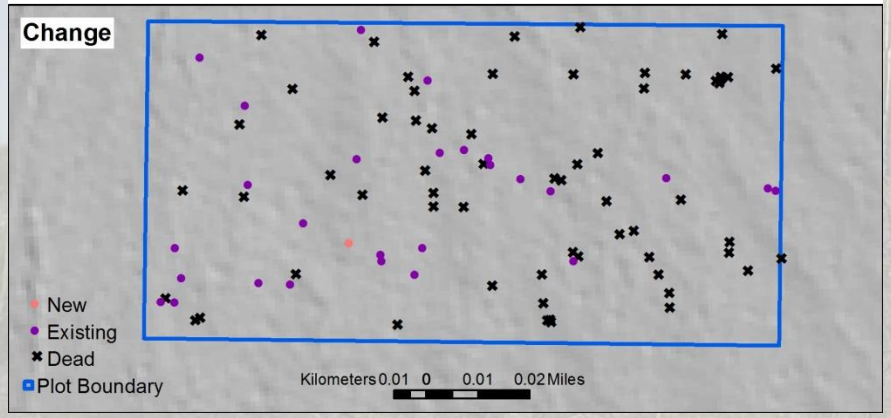
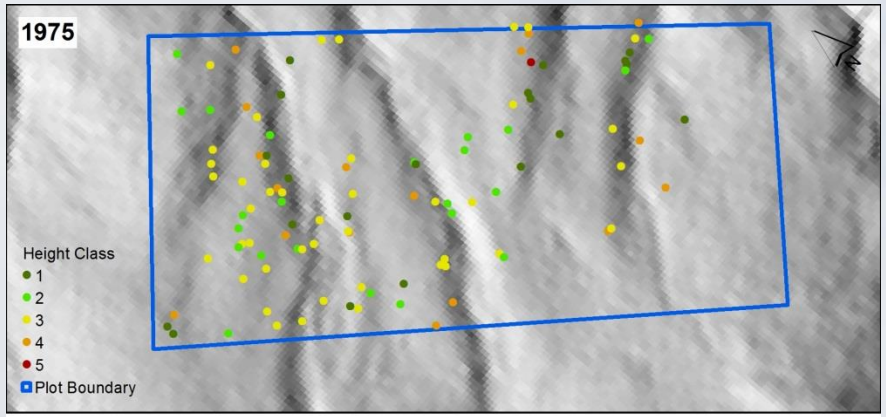

Change
New
Existing
Dead
Plot Boundary
Kilometers 0.01 0 0.01 0.02 Miles

75K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Height Class
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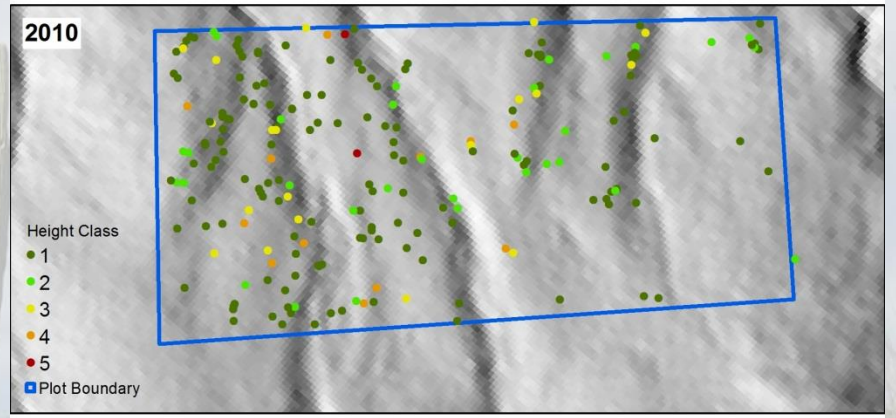
Plot Boundary


2010
Height Class
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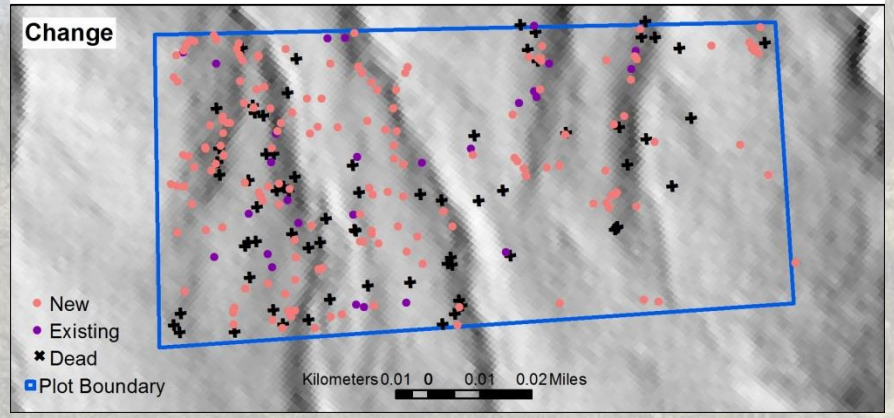
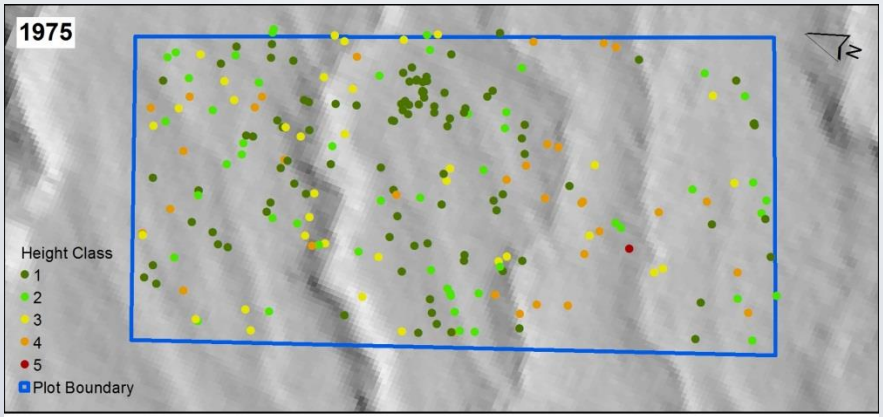
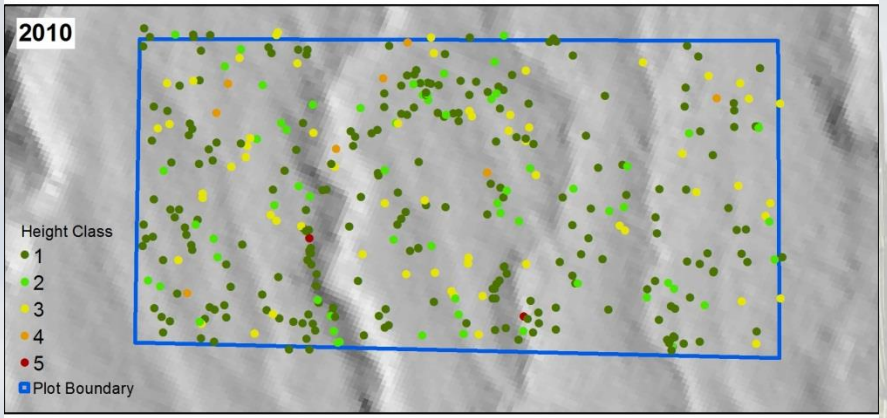
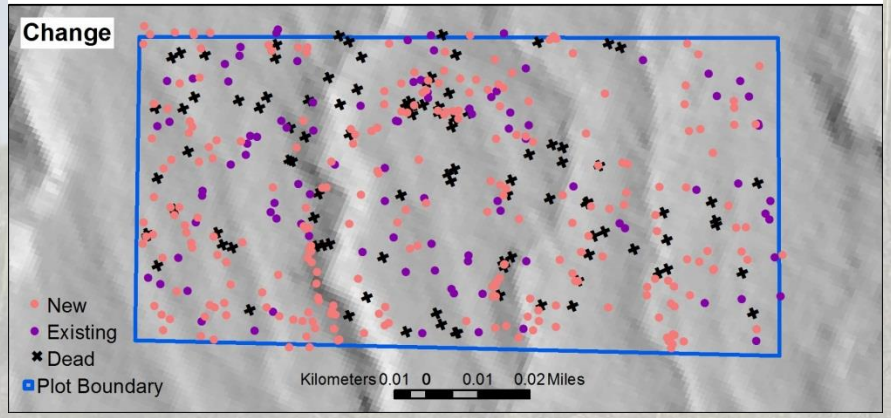
Plot Boundary


Change
New
Existing
Dead
Plot Boundary
Kilometers 0.01 0 0.01 0.02 Miles

75L



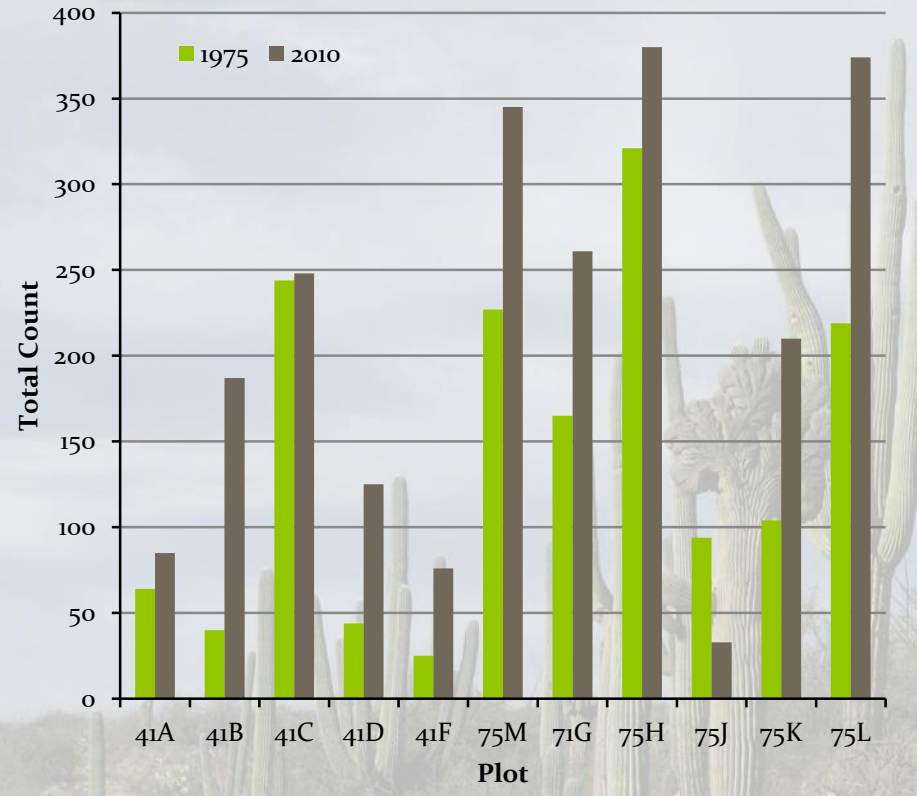


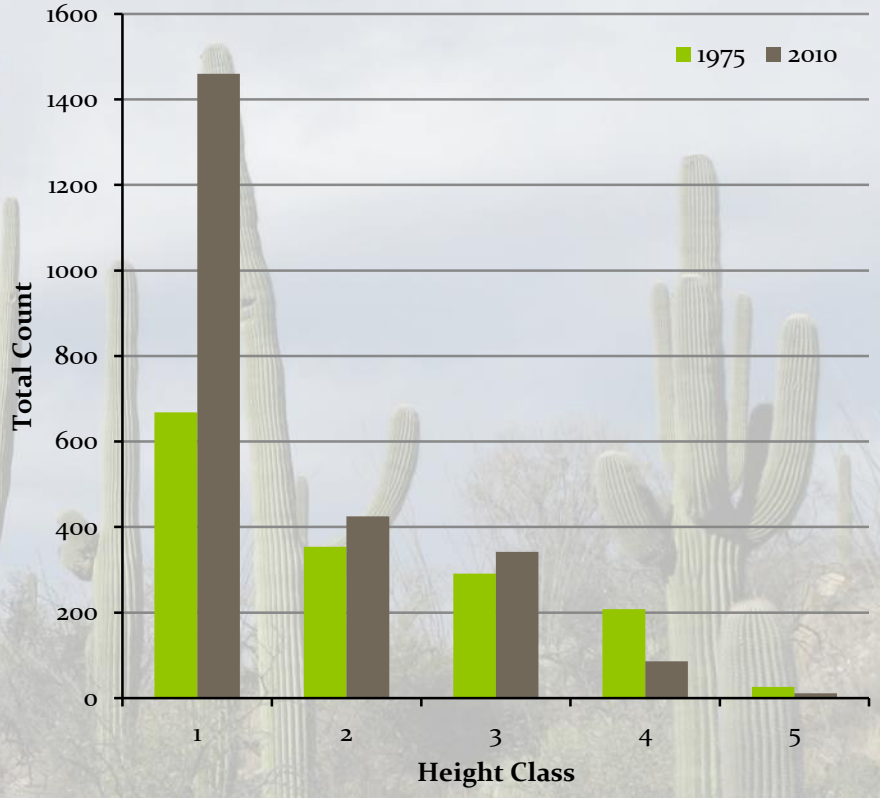


1975
Smallest= 0.014m
Tallest= 11.655m

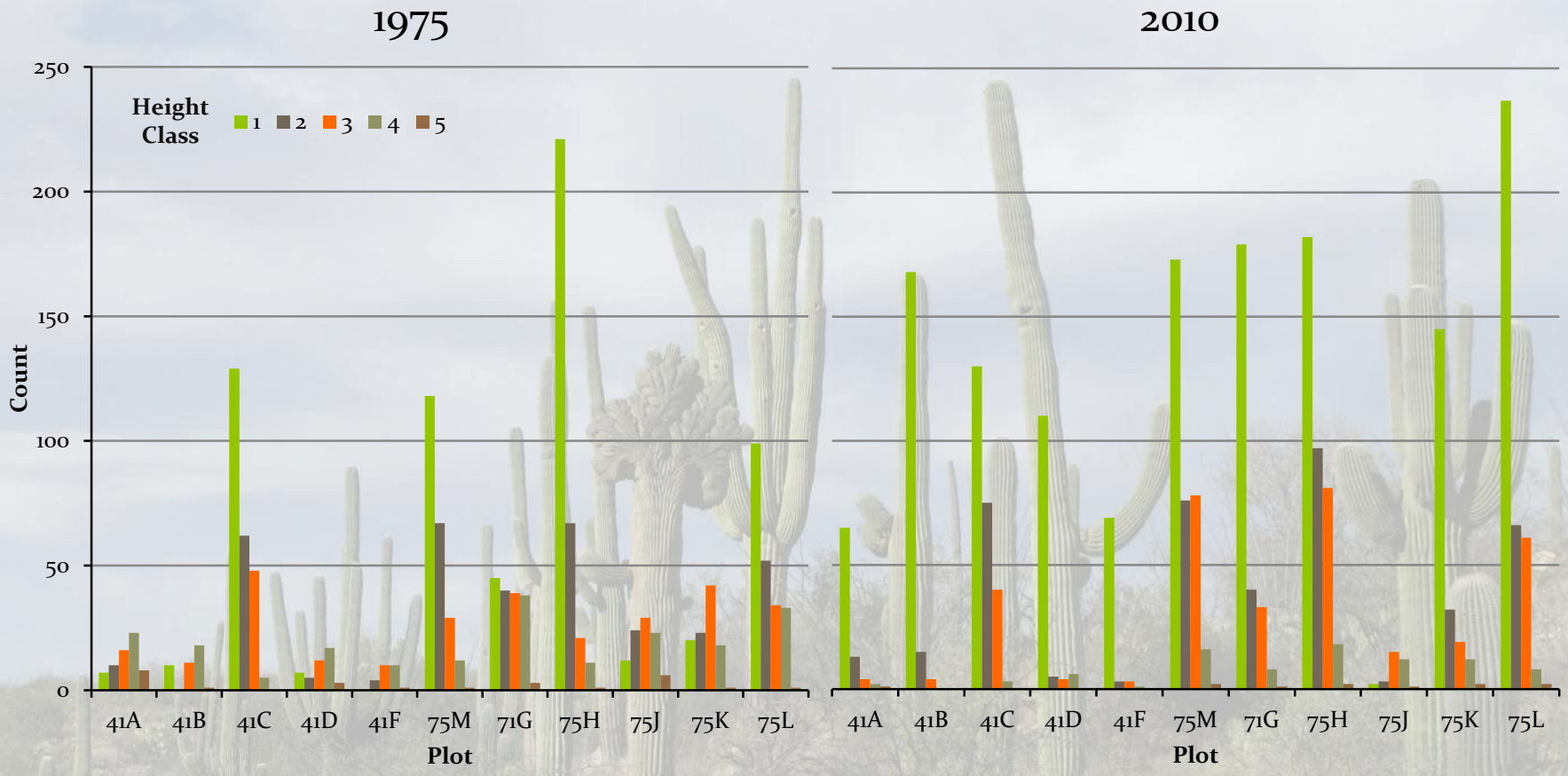
2010
Smallest= 0.014m
Tallest= 13m

Census Results

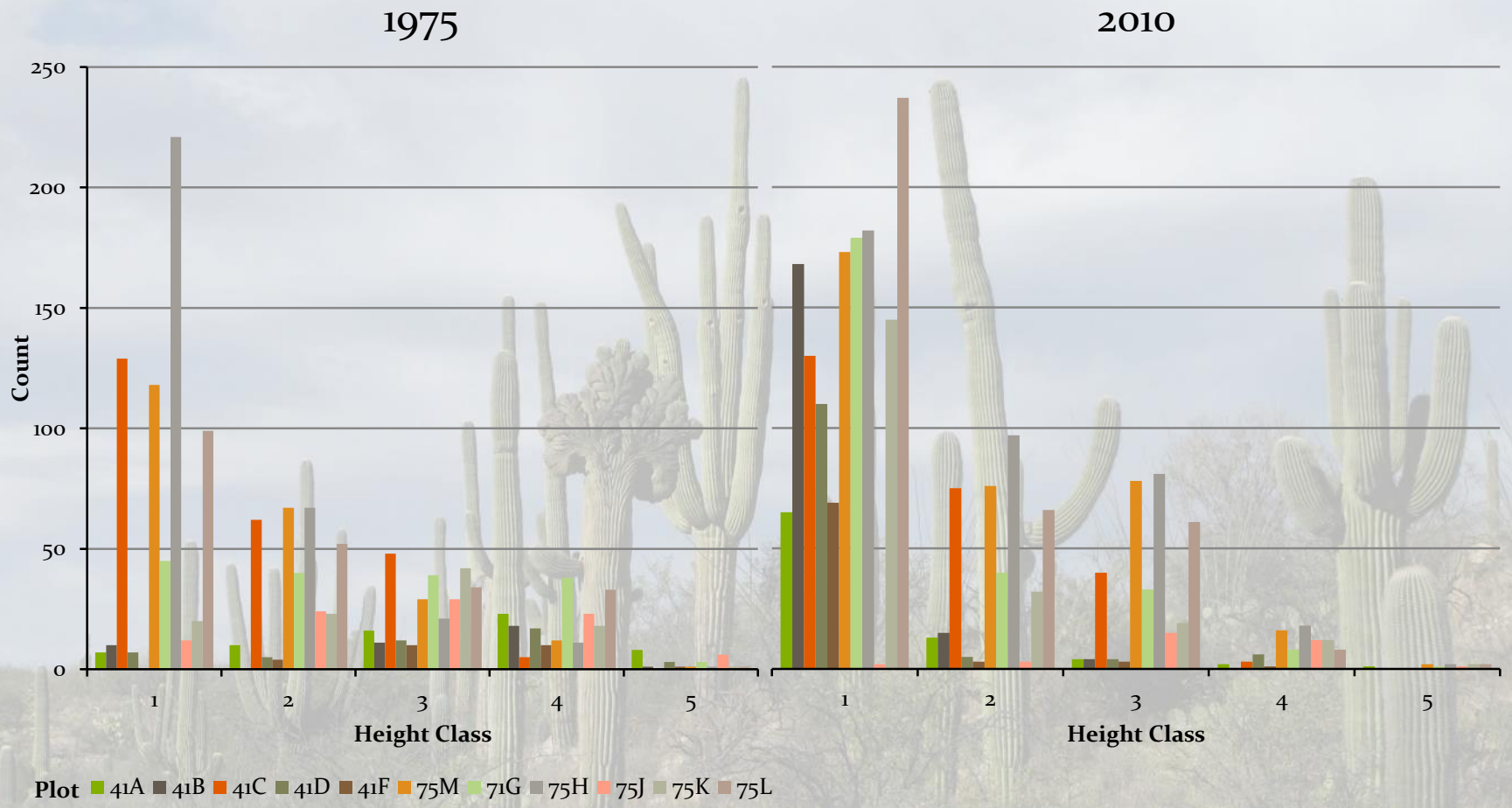




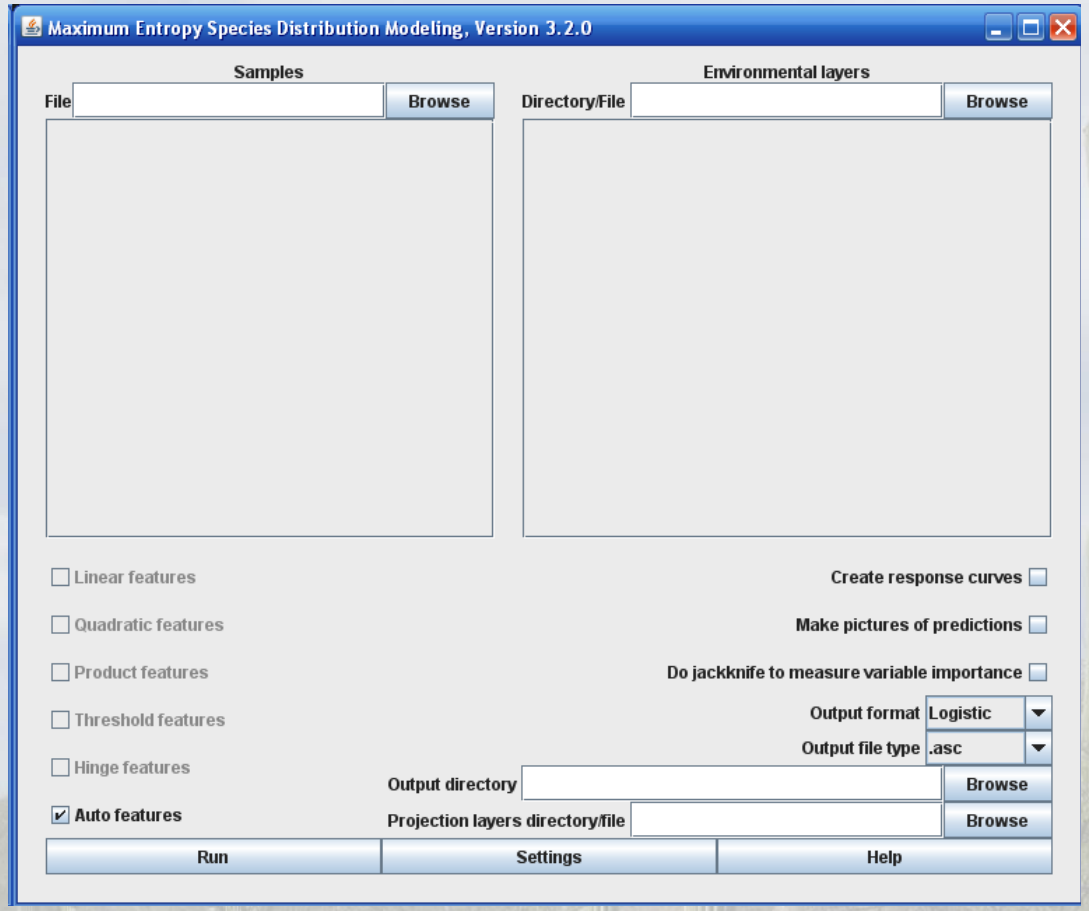
Census Results- Height Class by Plot



Census Results- Plot by Height Class

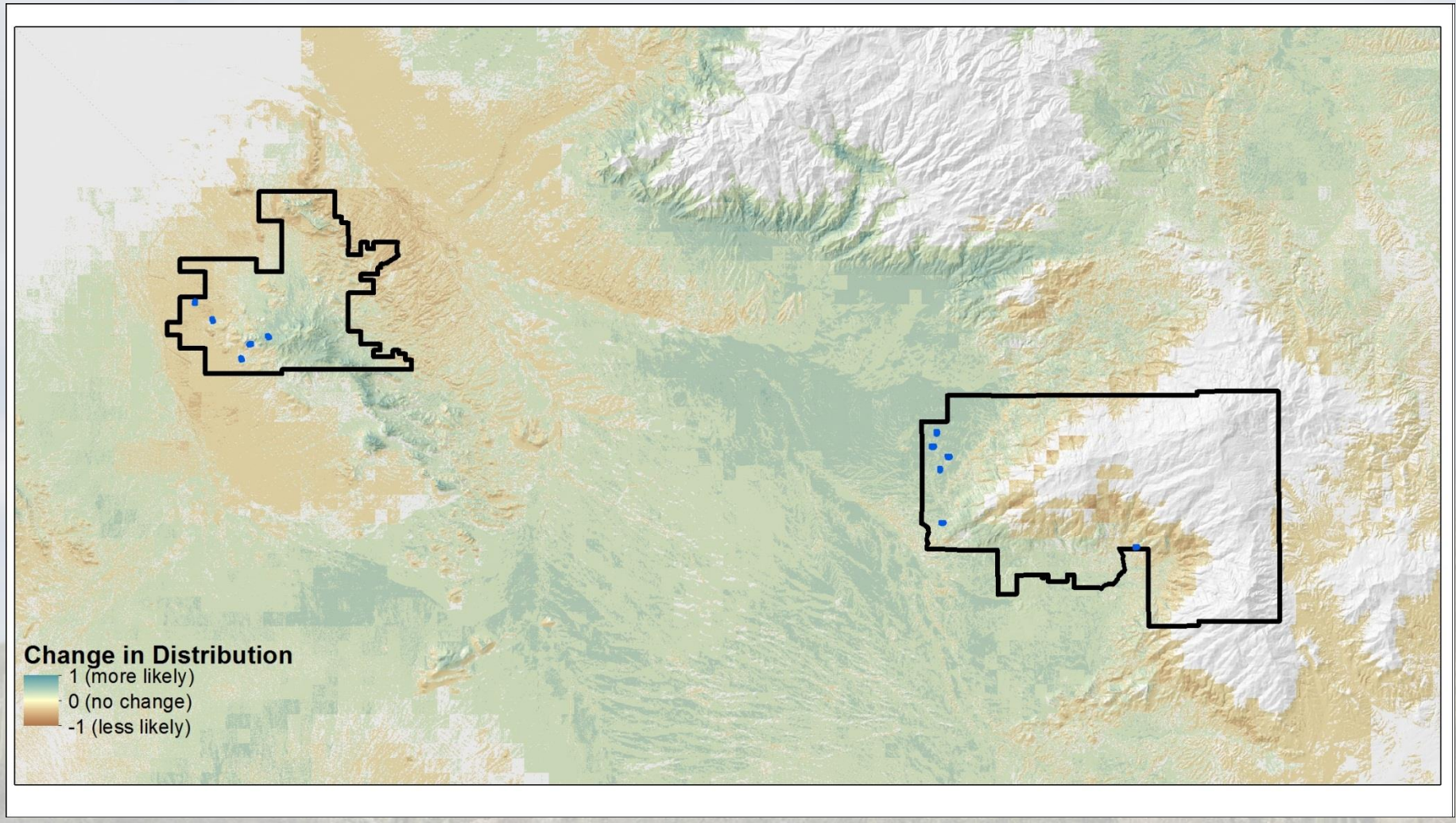


Maxent

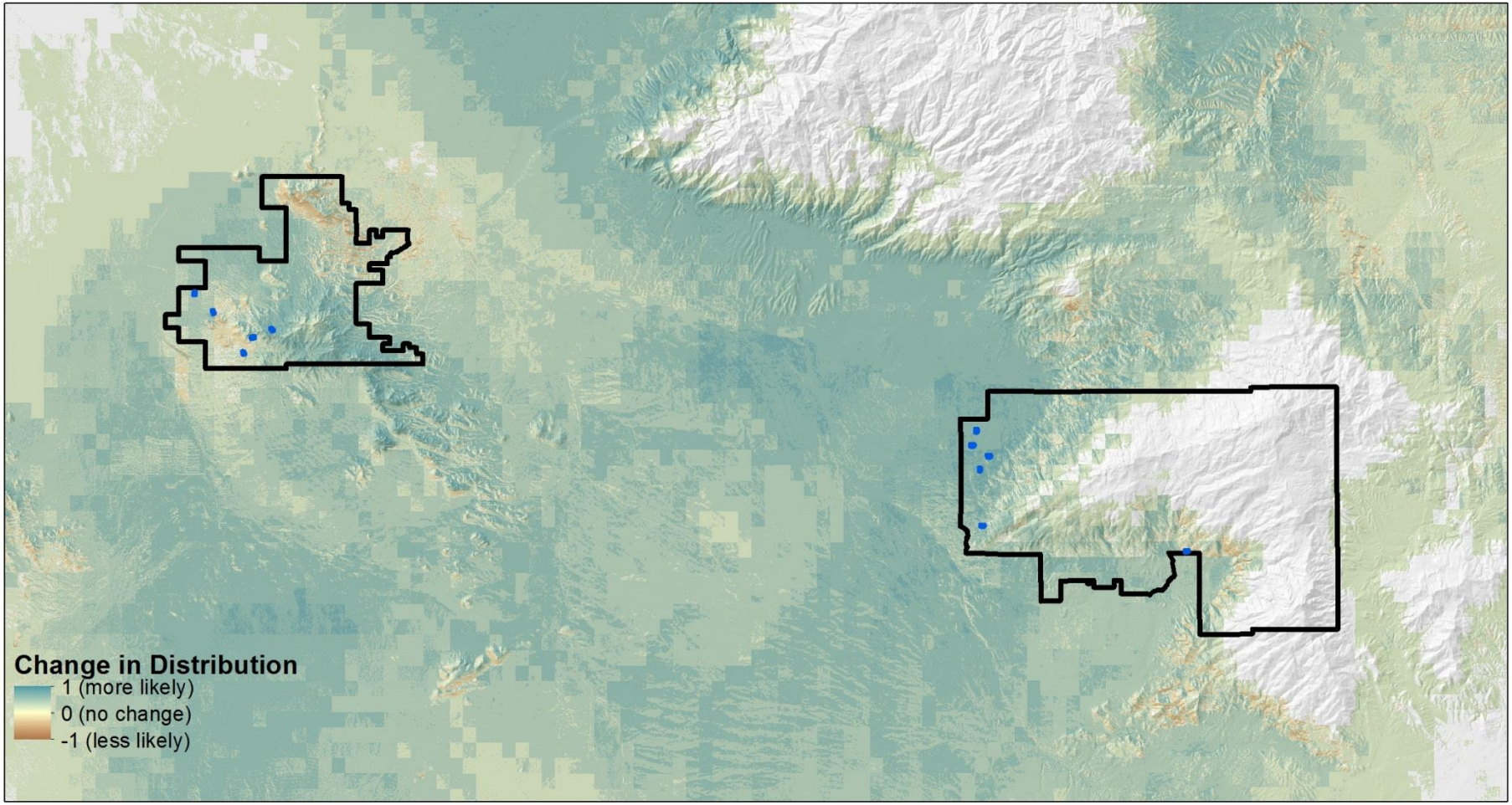


- *Remove duplicates: false*
- *Linear features: false*
- *Threshold features: false*
- *Hinge features: false*
- *Add all samples to background: true*
- *autofeature: false*
- *Default prevalence: 0.7*

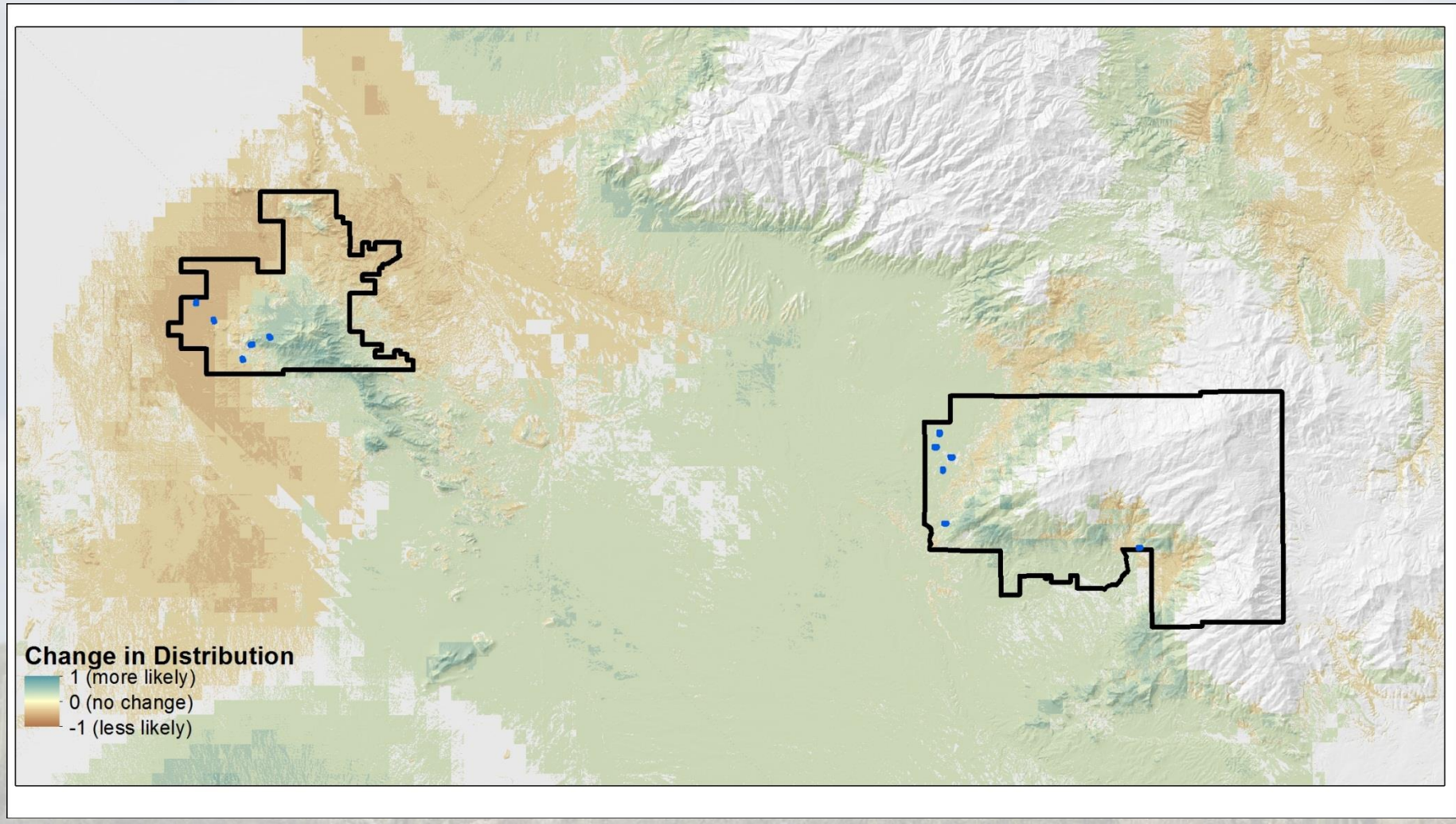
MaxEnt Results- Total Count



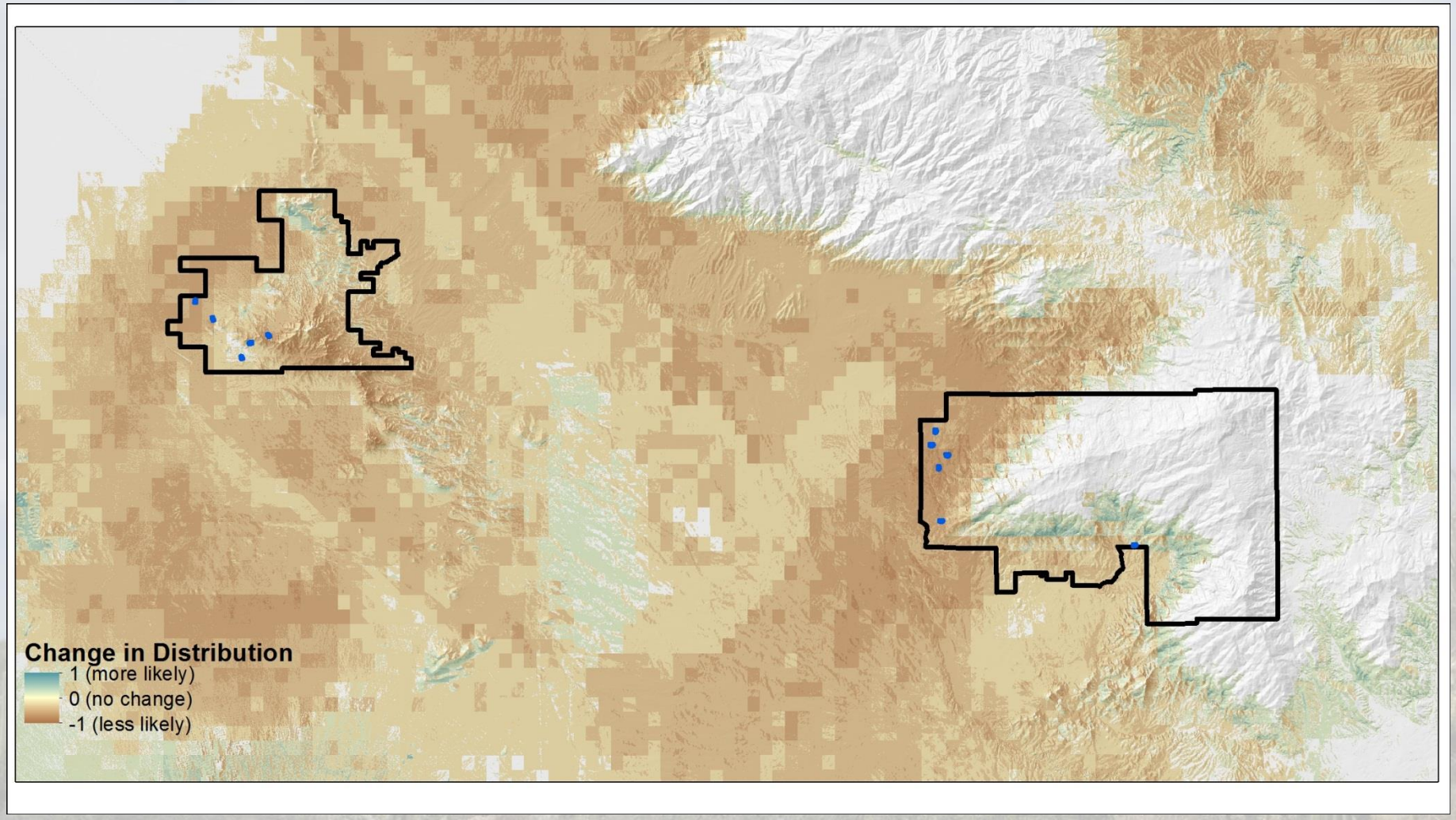
MaxEnt Results- Height Class 1



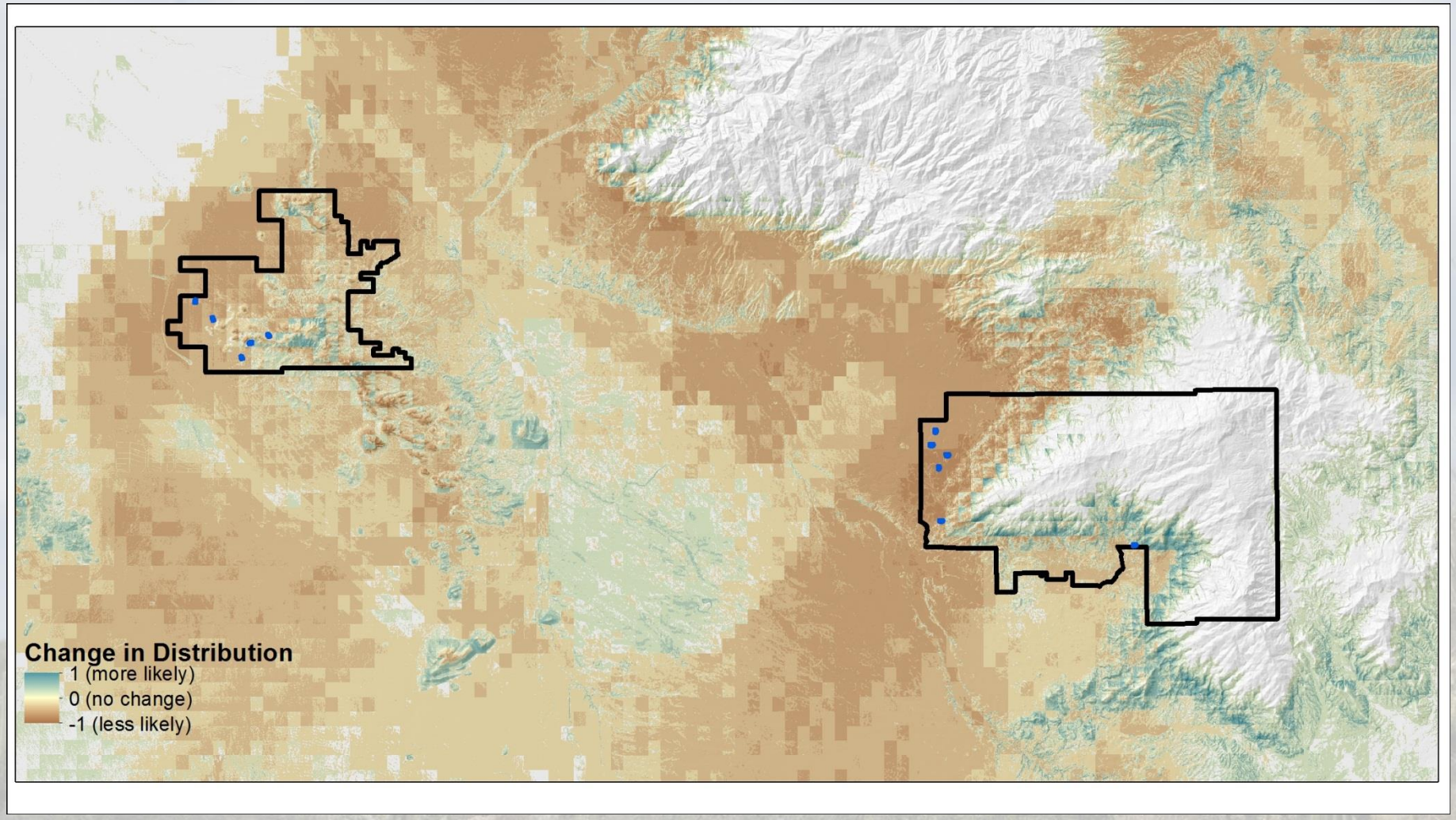
MaxEnt Results- Height Class 2



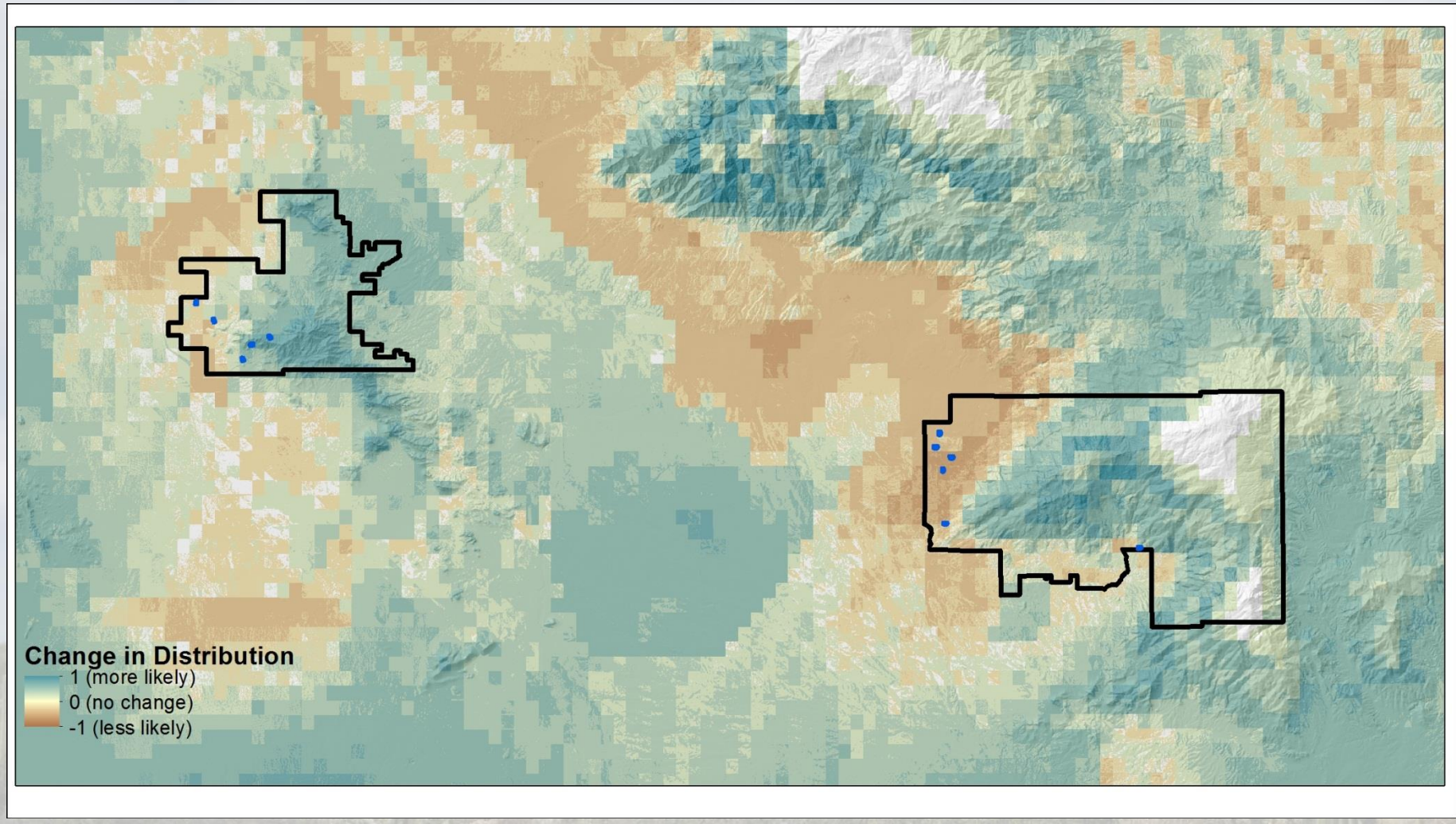
MaxEnt Results- Height Class 3



MaxEnt Results- Height Class 4



MaxEnt Results- Height Class 5



Result Summary

- All models show a change distribution
  - 50% increase in saguaro population on the 11 plots
    - Largest increase= 368% on 41B
    - Only decrease= -65% on 75J

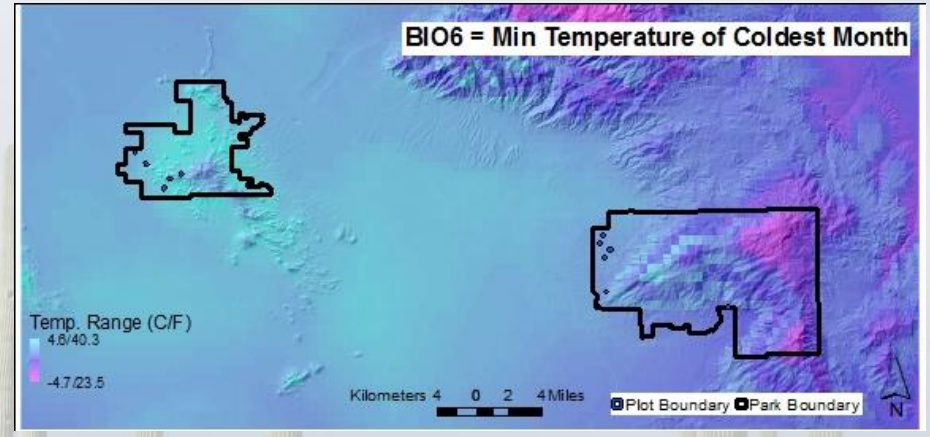
Height Class	1	2	3	4	5	Total
Percent Change	119%	20%	18%	-59%	-58%	50%

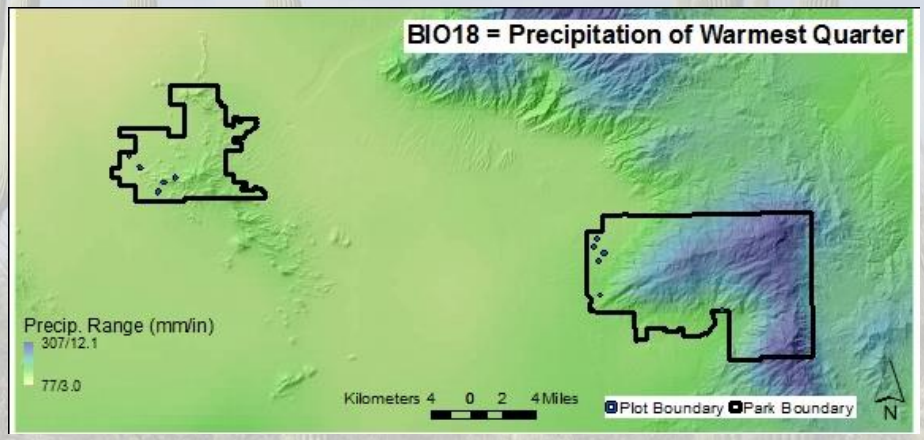
- Models showed overall more suitable habitat; RMD more "green", except higher elevations, TMD more "brown" except higher elevations
  - Height class 1 a LOT more green, some uphill movement
  - Height class 2 more lighter green
  - Height class 3 a LOT more brown
  - Height class 4 more brown
  - Height class 5 more green at TMD and in higher elevation, more brown where usually expect to find saguaros

Environmental Variables

For most models:

- Most influential as the only variable = BIO6: minimum temperature of coldest month
- Most influential when removed= BIO18: precipitation of warmest quarter
  - 1975 HC4 added BIO14 Precipitation of Driest Month when variable removed
- Least influential variables= aspect, slope, BIO2: mean diurnal range, BIO3: isothermality, BIO5: max temperature of the warmest month, BIO7: temperature annual range and BIO15: precipitation seasonality





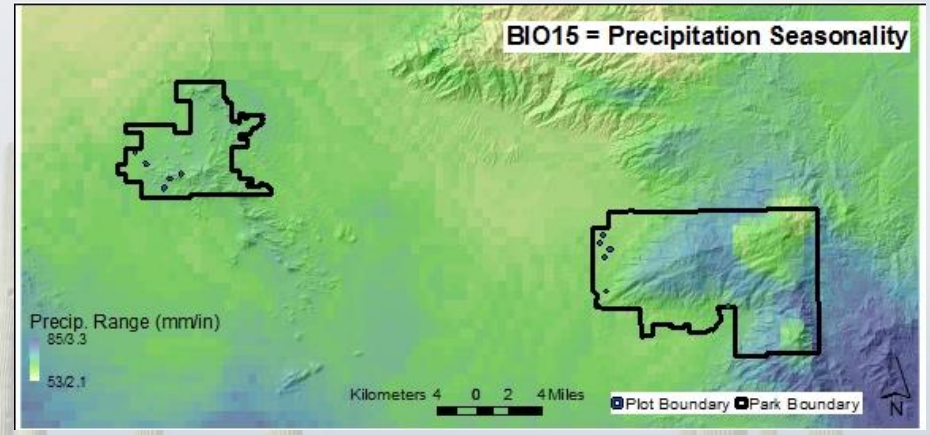
Environmental Variables

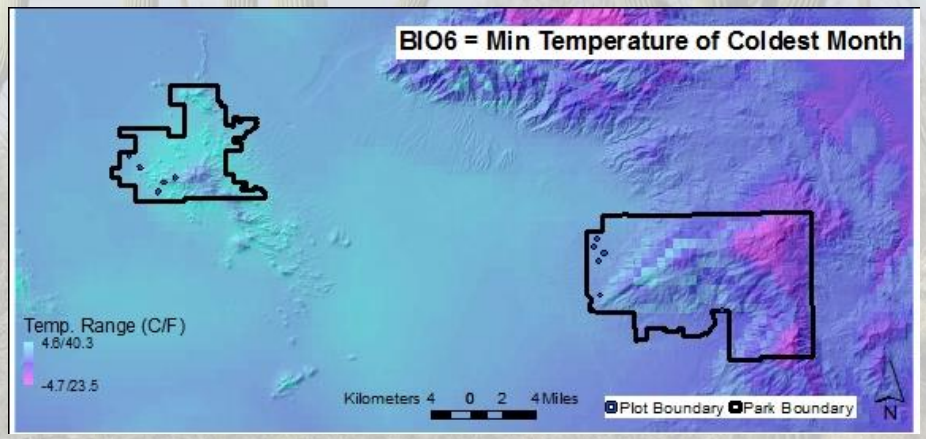
1975- height class 5:

- Most influential as the only variable = BIO15:precipitation seasonality and BIO18: precipitation of warmest quarter
- Most influential when removed= elevation, BIO1: annual mean temperature, BIO8, 9, & 11: mean temperatures of wettest & driest & coldest quarters, and BIO13: precipitation of wettest month

2010- height class 5:

- Most influential as only variable and when removed= BIO6: minimum temperature of coldest month





Discussion

- Saguaros are greatly influenced, as supported by the published literature, by summer rains and winter freezes
- More suitable habitat does not mean more saguaros, just more places saguaros can exist
  - i.e. height class 5 had a 58% decrease in population, but model showed more likely habitat
- Less suitable habitat does not mean no saguaros
  - i.e height class 3 had an 18% increase in population, but model showed a lot less likely habitat

Discussion cont.

- The sample size is relatively small compared to the actual population
- Plot locations do not provide complete coverage of area
  - Necessitated model variable adjustment

Future Research

- Additional data with a larger geographic representation, especially in higher elevations
- Long-term monitoring should continue
- Repeat census in 10 years
- Additional environmental variables: soil, vegetative cover (nurse trees), fire, invasive species, urbanization
  - Comparing saguaro habitat with other species
- Predict possible changes with corresponding climate scenarios, or changes in management

Questions